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Abstract. The purpose of this study is fish species identification using acoustic target strength (TS). *In situ* measurement has been deployed at the South China Sea of Terengganu Malaysia using Furuno FQ-80 Scientific Echo Sounder which included in the research vessel of KK Senangin II. The transducer is placed 2.8 meter under sea surface while fish put in the net cage under the vessel. TS data have been collected independently for commercial fish in Malaysia, there *are Selar boops* (Oxeye scad), *Alepes djedaba* (Shrimp scad), *Megalaspis cordyla* (Torpedo scad), and *Decapterus maruadsi* (Japanese scad). TS value, depth, and position of specific target have been observed using echogram. TS of every species is different although similar size and at the similar range from transducer. Thus, the specific fish species has been identified based on its acoustic target strength.

Key Words: Target Strength, *Megalaspis cordyla, Alepes djedaba, Decapterus maruadsi.*

Abstrak. Tujuan dari paper ini adalah mempelajari identifikasi spesies ikan menggunakan kaidah Target Strength (TS) pada akustik. Pengukuran secara *in situ* telah dilakukan di Laut China Selatan, Negeri Terengganu, Malaysia menggunakan Saintifik Echo Sounder Furuno FQ-80 yang berada pada kapal penelitian KK Senangin II. Transduser ditempatkan pada 2,8 meter di bawah permukaan laut, sedangkan ikan ditempatkan dalam jaring yang berada di bawah kapal. Data TS dikumpulkan secara independen terhadap ikan komersial di Malaysia, yaitu *Selar boops* (Oxeye scad), *Alepes djedaba* (Shrimp scad), *Megalaspis cordyla* (Torpedo scad), dan *Decapterus maruadsi* (Japanese scad). Nilai TS, kedalaman, dan posisi setiap ikan secara khusus telah diobservasi menggunakan echogram. TS untuk setiap spesies ikan adalah berbeda walaupun ukurannya sama dan berada pada jarak yang sama dari transduser. Oleh karena itu spesies ikan dapat diidentifikasi berdasarkan nilai akustik target strength yang dimiliki secara spesifik oleh masing-masing ikan.

Kata kunci: Target Strength, *Megalaspis cordyla*, *Alepes djedaba, Decapterus maruadsi*.

Introduction. Fish are difficult to see and study in the ocean, thus acoustic is needed to achieve it. The subject of fisheries acoustics is part of science of underwater sound (hydro acoustics) which itself is a major subject area because of its importance in undersea warfare. There are two major divisions of hydro acoustic: active and passive acoustics. Active acoustic includes subjects such as echo sounder and sonar, where pulses of sound are transmitted into the water and reflect off objects such as fish, submarines, or the bottom (Horne 2000).

Subject area of the course in hydro acoustic techniques applied to fish detection and abundance measurement usually referred as Fisheries Acoustics (Biosonic 1989). Size and reflectivity of sound by object are combined into a parameter called the backscattering cross section, which is essentially the acoustic size of the object. This parameter usually expressed in logarithmic and called the target strength (TS) in dB unit. Acoustic backscattering by fish depends on fish size, anatomical characteristics, morphology of the body, swim bladder, and location in the acoustic beam (Jech & Horne 2002; Sawada et al 2002).

The air filled swim bladder is the most important factor affecting acoustic backscattering in fish. An outstanding problem in fisheries acoustic is the depth and pressure dependence for TS of swim bladder. When fish dive, their swim bladders are compressed as a result of the increase in pressure at greater depths. The swim bladder of fish has been show to decrease as fish go deeper, according to Boyle's pressure law. Consequently, the target strength of these fish also decreases (Horne & Clay 1998).

TS of fish can be identified in two ways-determinations, which is *in situ* measurement in the natural habitats of marine and *ex situ* with a pond in the laboratory experiments with artificial habitats are created equal with the situation in the sea. *In situ* measurements incorporate ping-to-ping variability from ensonified organisms but do not permit independent measurement or the manipulation of sources that influence TS. *Ex situ* measurements using restrained fish of known length allow TS to be measured while controlling tilt and depth.

This study discusses the identify the TS using *in situ* measurement of any fish species using of commercially fish in South China Sea of Malaysia, there are *Selar boops* (Cuvier, 1833) (Oxeye scad), *Alepes djedaba* (Forsskål, 1775) (Shrimp scad), *Megalaspis cordyla* (Linnaeus, 1758) (Torpedo scad), and *Decapterus maruadsi* (Temminck & Schlegel, 1843) (Japanese scad) (taxonomy according to Fishbase 2008). FQ-80 Echo Sounder has been used to measure the TS.

Acoustic Target Strength. Size and reflectivity of sound are combined into a parameter called the backscattering cross section (σ_{bs}), which is essentially the acoustic size of the object. The backscattering cross section can be expressed as the amount of reflected sound intensity measured one meter away from the target, relative to the amount of energy incident upon the target, as shown in Figure 1. This parameter usually expressed in logarithmic then called the target strength (TS) and expressed in dB as shown in below (Biosonic 1989).

$$TS = 10\log\left(\frac{I_r}{I_i}\right) \quad (1)$$

$$TS = 10\log\left(\frac{\sigma_{bs}}{4\pi}\right) \quad (2)$$

$$TS = 10\log(\sigma_{bs}) \quad (3)$$

Where

I_r = Intensity reflected from target
I_i = Intensity incident on target
σ_{bs} = Backscattering cross section

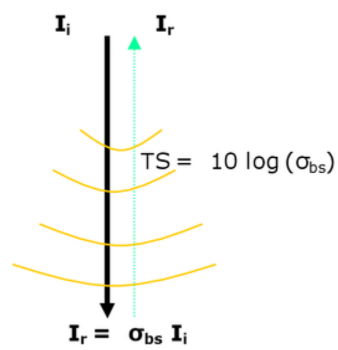


Figure 1. Target strength.

Aquatic organisms are complicated scatters by nature of their shape (cylindrical or spheroid), deformation (curvature of the body and swim bladder), and composition (exoskeleton, muscle, bone, fat presence and shape of swim bladder) (Horne & Clay 1998; Horne 2000). Otherwise, three primary biological factors influence the scattering of sound by aquatic organisms: swim bladder presence, organism length, and organism behavior (Horne & Clay 1998). Frequency also influences the amount of sound reflected by fish (Hazen & Horne 2003). In other words, TS of fish is influenced by several factors including orientation of fish relative to the transducer, the ratio of acoustic wavelength to fish length, and physiological condition (Horne 2003).

Variability in reflected sound is influenced by physical factors such associated with the transmission of sound through a compressible fluid, and the biological factors associated with the location, reflective properties, and behavior of the target (Horne 2000). Biological variation in backscatter of fish is dependent on behavioral, morphological, ontogenetic, and physiological factors (Foote 1990a; Ona 1990). The definition of ontogeny is restricted to the development and growth of the fish body and swim bladder. Physiology is restricted to fish feeding and gonad development through the reproductive cycle. Behavior includes the tilt and roll of individual organisms as well as the aggregation (i.e. shoaling) and polarized movement (i.e. schooling) by fish groups (Horne 2003).

The presence of a swim bladder is the primary biological factor influencing the amount and variability of backscattered sound from a fish. Swim bladder size and the angle relative to the longitudinal or sagittal axis of the fish body will determine the amount of sound reflected back to a transducer. Fish varies on swim bladder presence. Any fish have no swim bladder, single swim bladder, and dual swim bladders. Indian mackerel (*Rastrelliger kanagurta* (Cuvier, 1816)) is fish without swim bladder. In this study, all of fish have one swim bladder as 'typical' fish anatomy. Some species of fish even differ in anatomy. Lavnun (*Acanthobrama terraesanctae* Steinitz, 1952) from Lake Kinneret, better known as the Biblical fish from the Sea of Galilee, have a dual-chambered swim bladder (FAR 2009). The anterior chamber aids in hearing and helps to maintain buoyancy while the posterior chamber is the primary buoyancy control organ.

The swim bladder is considered to be responsible for most of the fish's acoustic backscattering energy (Foote 1990b) and consequently its TS. Natural variations in swim bladder volume and shape may cause variation in fish TS. The important factors that are assumed to alter the TS significantly are stomach content, gonads, body-fat content, pressure, and tilt angle (Jorgensen 2003). The swim bladder is an oval-shaped sac found in the fish's abdominal cavity, which at different times can be filled with varying amounts and compositions of gases (same as atmospheric gases; carbon dioxide, oxygen, and nitrogen). The bladder has developed as an extension of the gut wall (Martin 2000).

The swim bladder's main function is that of a hydrostatic organ. Neutral buoyancy, the ability of an organism to use little or no energy to stay at particular levels of water, is achieved through the expanding and shrinking of the swim bladder due to varying gas pressures. Fish swim bladder volume will change according to Boyle's law (Mukai & Iida 1996). When fish dives, its swim bladder is compressed as a result of the increase in pressure at greater water depths. So in order for the fish to return to its former, higher level in the water, the swim bladder must be reinflanted. Therefore, the most essential function of the swim bladder is the regulation of gases coming in and out of the fish's body. Thus it is necessary for fish to be efficient controllers of their buoyancy.

An air-filled swim bladder can contribute up to 90% of backscattered sound (Sawada et al 2002; Foote 1990b; Abe et al 2004). Theoretical calculation of TS is possible using the exact shape of the swim bladder (Foote 1985). Length, tilt, and depth influence the shape or orientation of the swim bladder and a major influence on TS and also influence the amount of sound reflected by a fish (Hazen & Horne 2003). For typical fish lengths (1-100 cm), swim bladders scatter sound over range of three orders of frequency magnitude (hundreds of Hz to hundreds of kHz). Backscatter intensities of fish without swim bladder are much lower than any swim bladder species (Gauthier & Horne 2004). Acoustic scattering by a swim bladder is four or more times greater than the scattering by fish bodies at any given frequency (Horne & Clay 1998).

***In Situ* Measurement**. *In situ* measurement using echo sounder can be explained as schematic as shown in Figure 2. TS of fish has been identified using research vessel in the natural habitats (sea). *In situ* measurement is a method that used by researchers for any fish, location, and conditions, such as acoustic observation in the Bay of Biscay in 1996 (Masse 1996), *in situ* measurement for Young hairtal (*Trichiurus lepturus* Linnaeus, 1758) in the Yellow Sea using scientific echo sounder installed on a fishing vessel (Zhao 2006), Chilean Jack mackerel (*Trachurus murphyi* Nichols, 1920) in the off Chile (Pena 2008), and using multiple-frequency in the Mid-Atlantic-Ridge and the Gulf of Alaska (Anderson & Horne 2007). Sound produced such as by Herring (*Clupea harengus*) using bubble release (Wahlberg & Westerberg 2003) is rule out in this discussion. *In situ* measurement at the South China Sea of Malaysia using commercial fish of *Rastrelliger kanagurta*, *Atule mate* (Cuvier, 1833), and *Thunnus tonggol* (Bleeker, 1851) were studied more than 10 years ago (Hassan 1999). No measurement thereafter of TS using another species from South China Sea of Malaysia.

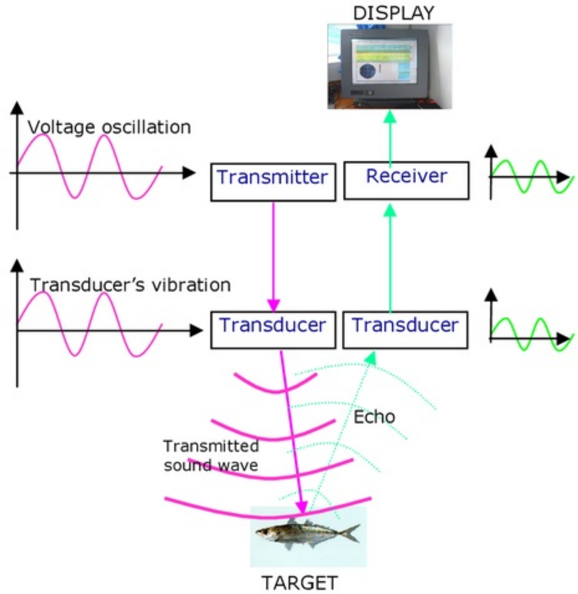


Figure 2. Schematic of *in situ* TS measurement.

Materials. Materials for this study are echo sounder equipment of Furuno FQ80 that included in the Research vessel; floating cage for measurement activity and life fish saving; net for life fish sample in underwater, life fish sample, weight and length meter; boat.

Furuno FQ 80 Echo Sounder which included in the research vessel KK Senangin II as shown in Figure 3(a) has been used. This research vessel owned by South East Asia Fisheries Department and Ecosystem Centre – Marine Fishery Resources Development and Management Department (SEAFDEC-MFRDMD), Kuala Terengganu, Malaysia. Scientific Sounder is designed and constructed to meet the rigorous demands of the marine environment. The FQ-80 is a scientific echo sounder for assessing fish, plankton, biomass, etc. It transmits an acoustical pulse through water and measures the strength of the returning pulse from fish and another biomass. The strength of the returning pulse depends on fish or fish school size. FQ-80 is included in the vessel of KK Senangin II with dual-frequency capabilities, low-frequency (38 kHz) and high-frequency (120 kHz) (Furuno 1999). One frequency will be presented to facilitate the analysis and comparison in detail. The transducer is positioned at the bottom of vessel, and 2.8 m from water surface. FQ 80 echo sounder deployed by researchers on the vessel with responsibility to handle the echo view software, assisted by divers to maintain fish and net position under transducers and covers in the echo sounder's beam, and the others crew to services the divers to supply net, cage, fish, and other materials.

The cage size 9 m x 9 m was made from wood materials and equipped with drum to make it floating on the sea as shown in Figure 3(b). The cage was designed and set up in the workshop, thereafter uninstall and carried by vessel to research location. The cage has been reinstall and floating on the sea to tethered net for life fish saving and maintain his physiological condition as along as one day before deploy the measurement.

Two types of nets are used in the measurement. First is cylinder net which 1.5 m diameter and 1.5 m length. This net is tethered at the floating cage and used for life fish saving before deploy measurement. The second net is 3 m x 3 m x 3 m size and positioned at below of the vessel to deploy fish TS measurement. Frame 9 m x 9 m size is used to maintain net position against sea wave underwater. Boat, net, and frame must be prepared too as shown in Figure 4. Frame and net underwater set up deployed by two divers or more. Boat is very useful for mobility on procedure of calibration, set up for underwater net and floating cages, maintain frame and net position, transportation from vessel to cage, and helping diver to maintain for frame position.

Target strength of four commercially fish species of South China Sea in Malaysia has been studied, there are *Selar boops* (Oxeye scad), *Alepes djedaba* (Shrimp scad), *Megalaspis cordyla* (Torpedo scad), and *Decapterus maruadsi* (Japanese scad). The photographs of these fish are shown in Figure 5. The detail characteristic of fish has been found in World Fish Center (2008). All of fish at the same family of Carangidae, order of Perciformers, and class of Actinopterygii. Maximum lengths of fish are 20, 25, 40, and 80 cm for *Selar boops, Decapterus maruadsi, Alepes djedaba*, and *Megalaspis cordyla*, respectively. Depth range of these fish are various from 0-20 m depth (*Decapterus maruadsi*), maximum 100 m (*Alepes djedaba* and *Megalaspis cordyla*), and maximum 200 m (*Selar boops*). The distribution of these fish can be found in World Fish Center (2008). After measurement has been finished, fish are measured for fork length and total length, width, also its weight individually using weight and length meter.

Methodology. The procedures below must be understood and detailed used in the measurement, there are calibration of echo sounder; net underwater set up; fish put in the net; TS recording; length, width, and weight measurement for fish.

The calibration is performed using a "calibration sphere", a sphere which has a precise TS value. The underwater setup for calibration is shown in Figure 6(a). Calibration allows the determination of backscattering strength or target strength of individual fish. The age of the transducer does not affect the calibration. However, an unclean or damaged transducer will affect the calibration. For this reason, any marine growth, barnacles, and oysters have to be removed from the transducer before calibration.

(a) Research vessel of KK Senangin II

(b) Floating cage

Figure 3. Research vessel and floating cage.

(a) Boat and net (b) Frame

Figure 4. Boat, net and frame ready to set up under vessel.

(a) *Selar boops* (b) *Alepes djedaba*

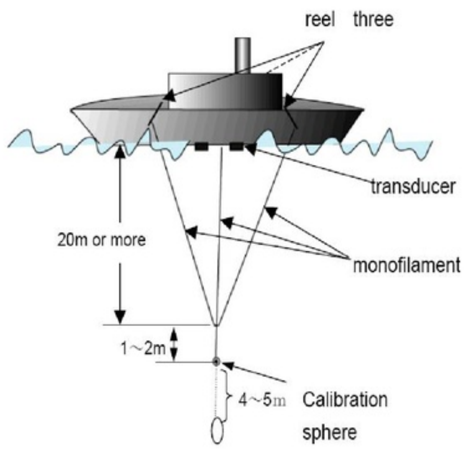
(c) *Megalaspis cordyla* (b) *Decapterus maruadsi*

Figure 5. Photographs of studied fish species.

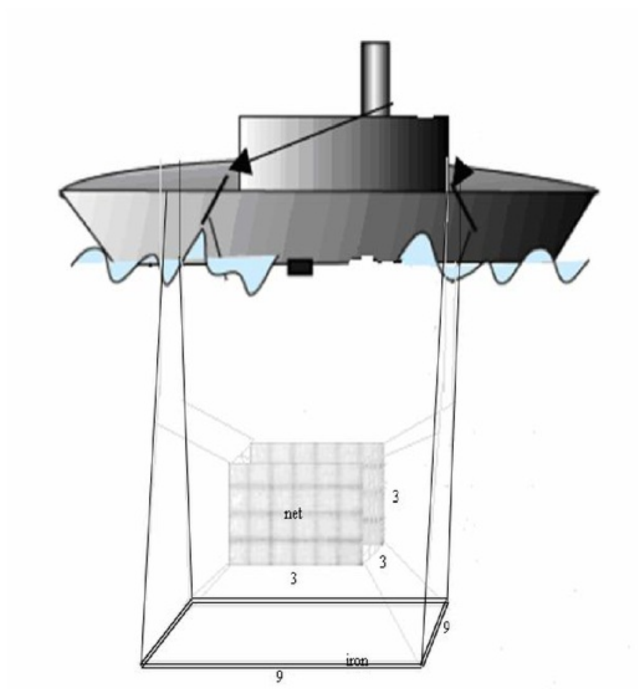
Calibration sphere of 38.1 mm diameter is bind to the net with nylon string. Deep sea multifilament #20 is used to the fishing line for the reel. The monofilament #10 - #15 is used to bind the sphere. Choosing time and location of calibration as follow is recommended to make ideally calibration, there are: the depth of the area from the transducer should be at least 20 meters; conduct the calibration in daytime hours and no tide; the water should be calm; void of small fish such as blowfish; the bottom is flat for at least 50 m; transparency is good and dispersion of particles is minimal. Small fish are not a hindrance to TS detection. However, small fish (such as blowfish) may chew through nylon strings, leading to loss of the calibration sphere. For that reason, avoid areas inhabited by small fish.

Processor and Analyzer Units are always on-line and display the same echo sounder picture (echogram) on the low or high frequency. While watching the Top View of TS display, the position of calibration sphere was adjusted so that the "red ball" on the scope comes to the center of x-y axis. The measured TS should be maintained in the range of ± 2 dB from calibration sphere TS or standard TS, i.e. is -42.30 dB and -40.10 dB for low and high frequency. The detail of TS standard for any frequency and calibration sphere as found in Furuno (1999). System menu is used to adjust the Source Level (SL) therefore the TS measured meet the standard TS.

The net size of 3m x 3m x 3m was placed at the bottom of the vessel as shown in Figure 6(b). The TS measurement of the cage with and without fish has been conducted. TS value, depth, and position of targeted fish can be viewed at every ping by recorded echogram using FQ-80 Analyzer. Orientations of fish are monitored by underwater video camera. Fish pick up from net in the cage using boat, then selected for size and species to meet the objective of this research then fish put in net underwater. Measurement was conducted after one night from fish put in the net in order to physiological stability of fish. After measurement had been finished, fish pick up from net underwater and its weight and length (fork length, standard length, and total length) been measured.



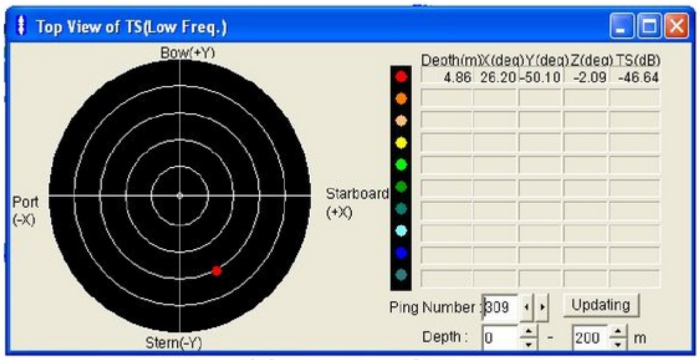
(a) Calibration



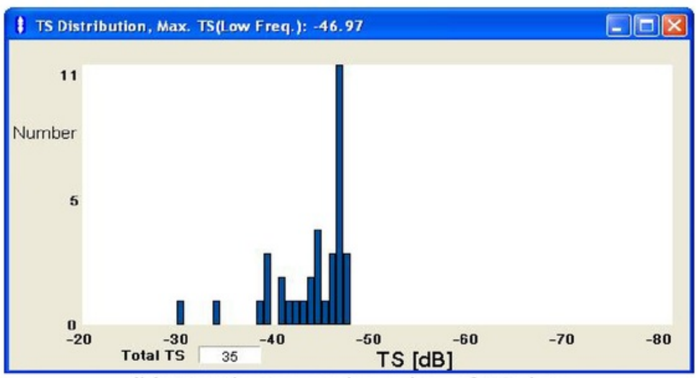
(b) Net cage under vessel

Figure 6. Set up of calibration and net cage under vessel.

Analysis of target strength measurement using four fish species with depth dependence had been conducted. TS value, depth, and position (x-y-z) of fish has been monitored at every ping by recorded echogram of FQ-80 Analyzer. TS value, depth, and position (x-y-z) of single fish which detected at every ping at low or high frequency has been observed from Top View of TS as shown in Figure 7(a). This display shows the direction and depth of single fish. The x-axis is starboard (+x) and port (-x), otherwise the y-axis is bow (+y) and stern (-y). Depth is measured from transducer. The z-axis is angle between fish and center of axis which measured from transducer. Distribution and total of TS data at every file can be viewed in Figure 7(b).



(a) Top view of TS



(b) Distribution and number of TS data

Figure 7. Top view of TS per ping and distribution of TS per file.

Results and Discussion. Echo sounder's implementation on TS measurement's results are discussed in this section included the calibration process and net measurement with or without fish. Observation of FQ Analyzer without net in the below of transducer is shown in Figure 8. This figure is captured from one file ID which has hundreds of pings. No TS recorded for this echogram for all pings. Calibration step for echo sounder has been done. The parameters used in this calibration process and found in Sunardi et al (2007).

The echogram of the calibration ball appearance has been observed as shown in the Figure 9 that various from 11.36 to 11.61 m depth from transducer, whereas the transducer is 2.8 m from the surface. This display is use type of raw data, the data sampled by each received signal. For 38 kHz, data is captured in the depth direction at intervals of 2 cm and the maximum range is 650 m. With those specifications, the FQ-80 provides faithful reproduction of the underwater image. This different depth of calibration ball has been influenced by sea wave. This echogram has 119 pings which single TS appearance detected on 97 pings for low frequency and 113 pings for high frequency. The averages of TS are -46.49 dB and -45.62 dB for low and high frequency, respectively. Calibration process and calculation are needed. The data on dB unit can not to be averaged directly therefore unit conversion from TS to σ_{bs} must be deployed. Summary of the calculation for calibration as listed in Table 1.

Figure 8. Echogram without net, no TS recorded.

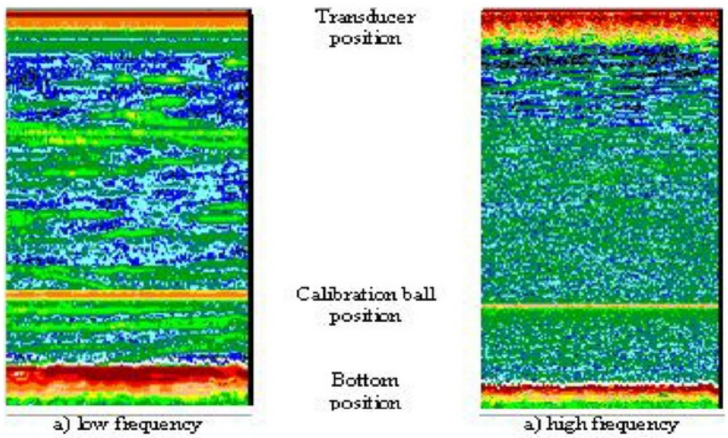


Figure 9. Echogram of calibration ball position, TS recorded on the specific depth.

Table 1

Summary of the calculation for calibration

No	*Record*	*Symbol*	*Calculation*
1.	TS standard (fix)	TS(f)	-38.3
2.	Current SL in the last measurement	SL	223.9
3.	Measured TS	TS	-40.52
4.	Measured TS – TS standard	TS - TS(f)	-2.22
5.	New SL used in this measurement	New SL = SL + (TS – TS(f))	-38.14
-	Back to step no 2 to 5 for new SL to TS standard very closely	-	-

After calibration set up has been finished, TS identification of fish has been deployed. These procedures has been done regarding measurement of TS using specific-species, there are Net underwater set up; Put fish into net underwater; Target strength recording; Measure for weight, width, length, and volume of fish. Fish has been sited in the net cage as long as one night before observed to confirming in the stable physiological condition. TS measurement using any fish in the net has been deployed for *Selar boops, Alepes* *djedaba*, and *Megalaspis cordyla* independently. *Decapterus maruadsi* has been measured using one fish only in the net. Every ping or file is contribute few TS record only caused by underwater sea wave due to the net out of beam, so the fish TS not recorded, therefore TS record of this data for any species is sum by many files and thousands of pings. Details of measurement for any species are described below.

The TS measurement of Selar boops has been conducted in Teluk Dalam, near from Redang Island, Terengganu, Malaysia at 27-29 March 2007. Total of 79 Selar boops has been sited in the net cage as long as one night. Total of 44 Selar boops remaining in the net cage has been used in TS measurement. The average and range of fork length, total length, and weight are 209.59 mm (175-233 mm), 236.16 mm (195-265 mm), and 165.00 gram (100-250 gram), respectively. The position of net and fish can be detected using echogram. Position of the upper net and lower net recorded at 2.3 m and 5.3 m from the transducer or 5.1 m to 8.1 from sea surface. The echogram of the fish appearance in the net cage has been observed, as shown in Figure 10. TS of every fish targeted had been viewed by recorded echogram of FQ-80 Analyzer.

Single fish TS value at low and high frequency at every ping were recorded using echogram. Single fish targeted then extracted as fish detected at depth, position (x-y-z) from transducer, and its TS. Selar boops has been identified at 6.98 to 7.69 meters of depth. Single fish TS detected at low frequency is ranging from -49.40 to -40.33 dB with the average of -46.49 dB. Otherwise the single fish TS at high frequency is ranging from -47.19 to -44.76 dB with the average of -45.96 dB. Sample of fish TS record with its positions are listed in Table 2. No significantly TS record differences between low and high frequency. For next discussion and other species in the next measurements were focuses on low frequency of 38 kHz only. Total 30 pings recorded whose record the TS with mean is -46.49 dB (minimum -47.40, maximum -38.33, standard deviation 2.869) as shown in Figure 11.

Table 2

Fish detected and its position

Ping number (Low/High Freq.)	*Depth (m)*	*X (deg)*	*Y (deg)*	*Z (deg)*	*TS (dB)*
308 (H)	4.61	48.20	-55.70	-2.32	-45.92
309 (L)	4.86	26.20	-50.10	-2.09	-48.64
345 (H)	4.61	29.40	-35.00	-1.46	-44.76
346 (L)	4.86	18.20	-40.70	-1.70	-44.67
380 (H)	4.61	23.80	-18.20	-0.76	-47.19
380 (L)	4.82	32.70	-25.30	-1.05	-48.60

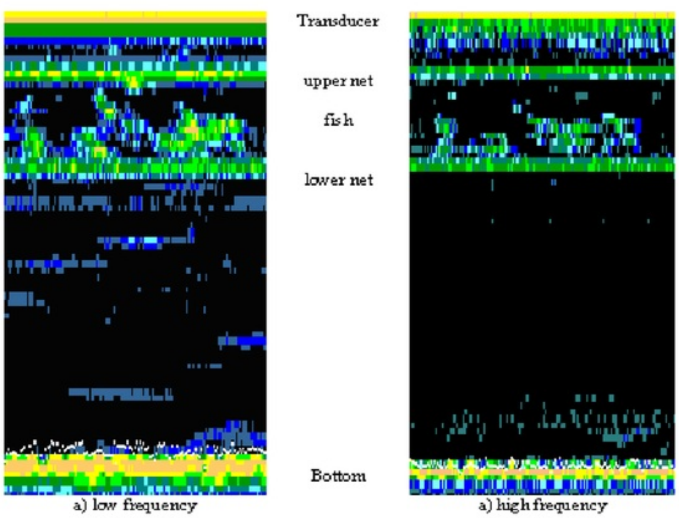


Figure 10. Echogram of fish between upper and lower net.

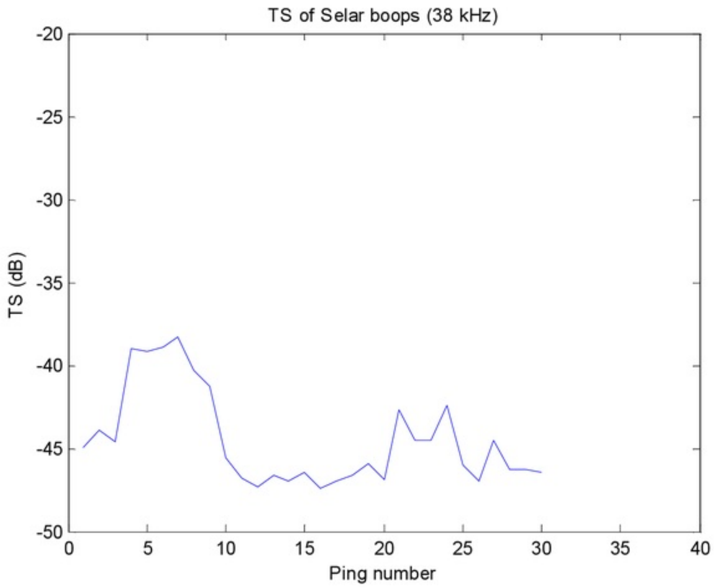


Figure 11. TS of Selar boops.

The TS measurement of *Alepes djedaba* has been conducted in Teluk Dalam, near from Redang Island, Terengganu, Malaysia at 28-30 May 2007. Total of 29 *Alepes djedaba* had been used in the measurement. Total of 2281 pings whose record the TS. Average of fish TS detected at 38 kHz frequency is -39.09 dB (minimum -48.17, maximum -28.58, standard deviation 4.585). This data shows that *Alepes djedaba* produce higher TS than *Selar boops*. Graph of TS can be viewed in Figure 12. No significance differences of fish depth in the net cage underwater (Sunardi et al 2008).

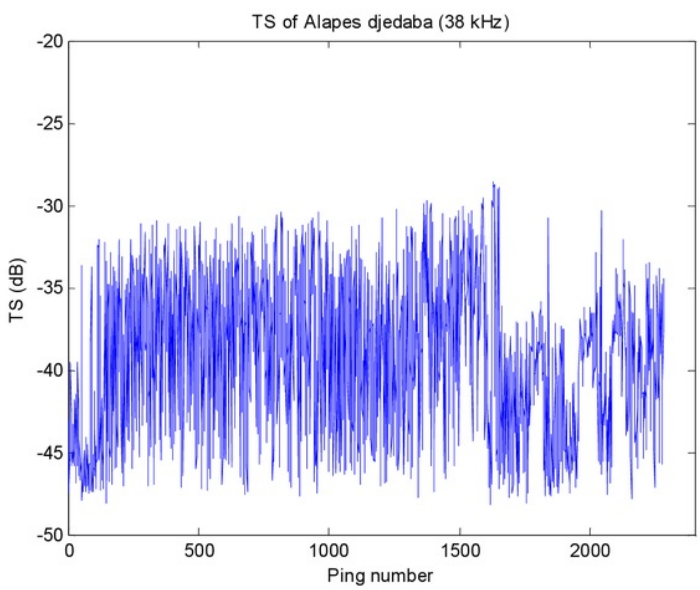


Figure 12. TS of *Alepes djedaba.*

The TS measurement of *Megalaspis cordyla* has been conducted in Teluk Dalam, near from Redang Island, Terengganu, Malaysia at 11-13 July 2007. Total of 9 Megalaspis cordyla had been used in the measurement. Total length has not been measured because the tail was broken. *Megalaspis cordyla* were detected at 8.8 to 10.6 meters of depth. Figure 13 shows that total 260 pings are recorded with average of TS -44.70 dB at 38 kHz frequency. Minimum, maximum, and standard deviation are -48.49 dB, -38.30 dB, and 2.206, respectively. Thus, *Megalaspis cordyla* although smaller body is produce higher TS (-44.70 dB) than *Selar boops* (-46.49 dB), but less than *Alepes djedaba* (-39.09 dB). The data can be compared with its length and weight data for these species as shown in Figure 14.

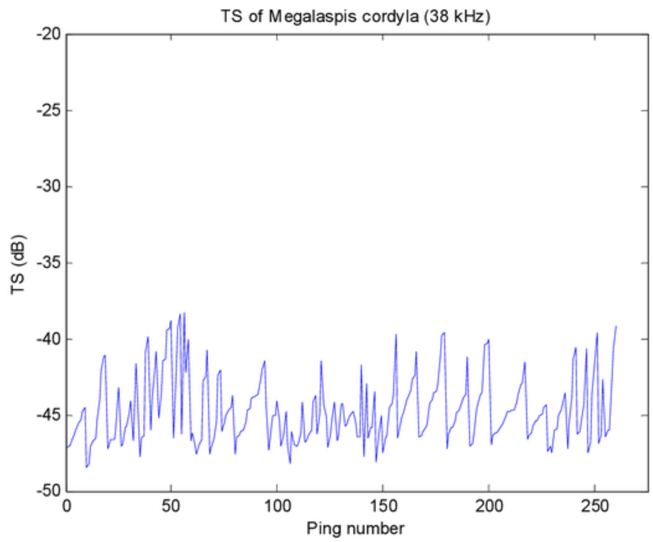


Figure 13. TS of *Megalaspis cordyla*.

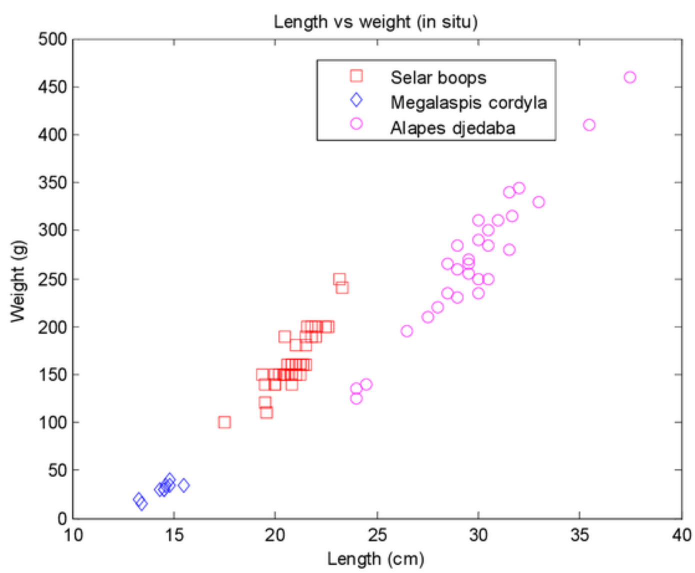


Figure 14. Length vs weight of *Selar boops, Alepes djedaba*, and *Megalaspis cordyla*.

TS measurement using one species only in the net successfully performs for *Decapterus maruadsi*. It has been conducted in the near from Kapas Island, Terengganu, Malaysia at 6-9 July 2008. This measurement using one fish which fork length of 12 cm, total length 15 cm, and weight 35 gram. Total of 98 pings of single fish are detected at low frequency. The average of TS is -54.19 dB which minimum -57.59 dB, maximum –47.40 dB, and standard deviations 2.089 and graphed in Figure 15.

The results of TS measurements for four species have been summarized as listed in Table 3. Each species has been identified based on its TS and increases sequentially are *Decapterus maruadsi, Selar boops, Megalaspis cordyla*, and *Alepes djedaba* from -54 dB to -39 at intervals of approximately 8 dB, 2 dB, and 5 dB, respectively. The measurement has been successfully deployed to identify the TS value for specific species of fish. Further development is needed to identify as many possible variations of species and size. Knowledge of the value of TS can be used to save time and costs involved in making the decision for fishermen to install a net or not in order to catch the fish. Presence or absence of fish, specific species, size, and depth if it could be found will more easily for the fishermen to decide what model to install the nets. The measurement be deployed for as many possible various species and size. Furthermore, the fish TS can also be used to determine the estimated stock of fish in the sea.

Table 3

Fish TS identification from *in situ*

Species	*TS (dB)*
Decapterus maruadsi	-54.19
Selar boops	-46.49
Megalaspis cordyla	-44.70
Alepes djedaba	-39.09

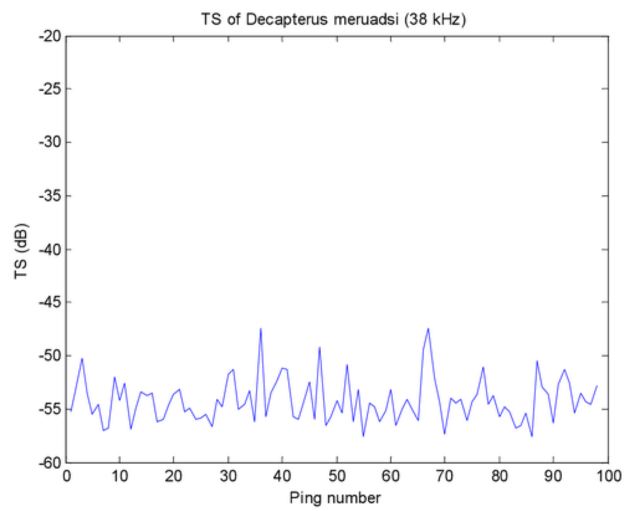


Figure 15. TS of *Decapterus maruadsi*.

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